IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308

https://doi.org/10.15623/ijret.2018.0705015 Received: 10-03-2018, Accepted: 21-04-2018, Published: 12-05-2018

COMPARISON OF COMPRESSIVE AND SPLIT TENSILE STRENGTH OF ARAMID FIBER REINFORCED CONCRETE WITH CONVENTION CONCRETE

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Abstract

Concrete has been the major component in the construction field since a long time, but it's strong in compression and weak in tension. ParaAramid fibers are one of the high-performance fibers with excellent mechanical and thermal properties. It has high tensile strength, high heat resistance, less wear & tear, less abrasive. This project work presents the state of art of knowledge of Para Aramid fibers, the production methods and review of tests on Para Aramid fibers as a strengthening material for concrete structures. In this study Mechanical properties of Para Aramid fibers will be carried out. An experimental program was planned in which cube specimens of size 150 x 150 x 150 mm were also tested to obtain its compressive strength and also cylinder specimens of size 100 mm diameter and 200 mm height were also tested to obtain its split tensile strength. The specimens incorporated Para aramid fibers in the mix proportions of 1%, 2%, 3% and 4% by weight of cement. While increasing the percentage of para aramid fibers with increases the compressive strength and split tensile strength.

Keywords: *Para Aramid Fibers, Shear Strength, Mechanical properties and Reinforced Concrete Beams.*

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1. INTRODUCTION

Cement concrete is the most widely used building material in the world because of its high strength and mouldability. As there is increase in infrastructure development, demand for the production of concrete has increased. Concrete is one of the major construction materials being used worldwide. Concrete is the composite material composed of cement, natural sand and natural aggregates. The materials which are used in the concrete are naturally available except cement, the use of concrete in the construction is increased now a day's. Concrete is currently the most widely used building material. Although many structures are built of concrete, there are still some limitations related to the use of conventional concrete, such as low tensile strength and almost no ductility.

Fiber reinforcement plastic (FRP) reinforcement has been utilized for concrete structure expecting its high durability to corrosion and insulation property. Types of fiber reinforcement plastic (FRP) are carbon fiber reinforcement plastic (CFRP), glass fiber reinforcement plastic (GFRP), steel fiber reinforcement plastic (SFRP) and aramid fiber reinforcement plastic (AFRP). AFRP has been expected to be applied to concrete structure.

The aramid fiber is first man mad organic high performance fiber.This is having a high enough tensile modulus and strength to be used as reinforcement in advanced composites was an Aramid fiber. The term "aramid" is short for "aromatic polyamide". Aromatic polyamides were first introduced in commercial application in the early 1960s, with a Meta aramid fiber produced by DuPont under the trade-name Nomex [1]. Aramid fiber is great composite material. Aramid fiber is 5 to 10 % higher mechanical properties then the other synthetic fiber. It is high durability to corrosion and insulation property [2]. Aramid fiber has better mechanic properties then steel fiber, glass fiber and polypropylene fiber. It has excellent heat and flame resistance [3].

Types of Aramid Fibers

It has generally two types i.e. para-aramid and meta-aramid fiber.

i. Meta Aramid fiber
ii. Para Aramid fiber

Para aramid fiber is a high tensile modulus, high heat resistance, highly oriented rigid molecular, rigid molecular structure and elasticity. Para aramid fiber have similar operating temperature to Meta aramid fiber. Para aramid fiber has 3 to 7 time's higher strength than the Meta aramid fiber. Para aramid fiber is used for a variety of reinforcements reflecting its high-tenacity. Para aramid fiber is used in concrete because of its light weight and durable material. It is used for fishing rod, body, floor and wall composite materials of air planes etc. [4].

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Properties

- High tensile strength
- High stiffness
- Low density
- Low creep
- Resistance to high temperature
- Electrical non-conductivity

Fig 1.1: Para Aramid Fiber

Advantages

- Aramid fiber resists elevated temperature therefore for making of protective clothing and fabric used near fire.
- Aramid fiber has non-conductive properties therefore it used like insulator for safety purpose.
- Kevlar has more resistance to fatigue.
- Aramid fiber is a light weight material.
- It has high strength.
- It has less wear and tear.

Disadvantages

- Aramid fiber is very sensitive in property. It degrades in contact of UV light
- Compressive strength of aramid fiber is very poor
- Aramid fibers are difficult to cut without of any equipment

2. MATERIALS AND METHODOLOGY

2.1 Materials

- **Cement**
  Ordinary Portland cement of 43 grades and specific gravity of 3.0 confirming to IS 269-1976[11] is used in the present investigation. It was tested for its physical properties in accordance with Indian Standard specifications.

- **Fine Aggregates**
  Fine aggregates was obtained from locally available river sand, clear from all organic impurities was used in this experimental program. The fine aggregates passing through 4.75 mm sieve and having specific gravity of 2.44 were used. The grading of fine aggregates was done and fall in zone III as per Indian Standard specifications.

- **Coarse Aggregates**
  The coarse aggregates used were non-reactive available from local quarry. The coarse aggregates passing through 20 mm and retained on 10 mm sieve were used in the present experimental program. The specific gravity of coarse aggregate is 2.81.

- **Water**
  Ordinary tap water used for all concrete mix.

- **Super plasticizer**
  Super plasticizer also called as high range water reducers are used in concrete as they permit the reduction of water to the extent of 30 percent without reducing the workability. The use of super plasticizer is practiced for production of flowing self-levelling, self-compacting and for the production of high strength concrete and high performance concrete.A commercially available Conplast sp430 DI was used for all concrete mix.

2.2 Methodology

To accomplish the above set objectives in the present study the mix design for high strength concrete for M40 was developed based on trial batches. 15 numbers of cubes and 15 cylinders with and without fibers have been cast for assessing the compressive and tensile strength of concrete.

Table 2.1: Concrete Mix Proportion

Water/Cement Ratio	Sand/Cement Ratio	Coarse Aggregate/Cement Ratio
0.43	1.55	2.40

Table 2.2: Fiber Mix Proportion

Type of fibers	Percentage of fibers
Pars Aramid fiber	1%
	2%
	3%
	4%

Table 2.3: Properties of Aramid Fiber

Fibers	Geometry	Average Diameter (mm)	Length (mm)	Tensile Strength (GPa)
Para Aramid	Fibrillated	1000μm	12 mm	3 GPa

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3. TEST RESULT AND DISCUSSIONS

3.1 Compressive Strength

The cubes of size 150 mm x 150 mm x 150 mm are tested in a servo controlled compression testing machine of 3000 kN capacity as shown in Fig. 3.1. The values of compressive strengths obtained are shown in Table 3.1 and Fig. 3.2. The compressive strength of para aramid fiber reinforced concrete cube increased by 12.48% in comparison to control concrete cube [11].

Fig 3.1: Compression test on cube

Table 3.1: Average Compressive Strength of Cubes

Specimen ID	Percentage of Fiber	Compressive Strength (MPa)	Average compressive strength (MPa)	
A1	0%		40.39	43.56
A2			40.16	
A3			45.15	
B1	1%		40.58	39.93
B2			36.44	
B3			42.77	
C1	2%		45.00	45.47
C2			46.55	
C3			44.88	
D1	3%		48.44	48.25
D2			47.00	
D3			49.33	
E1	4%		52.00	55.62
E2			55.55	
E3			59.33	

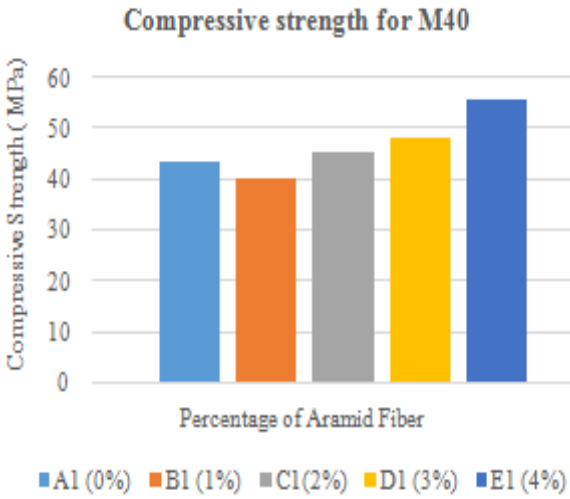

Fig 3.2: Comparison of Compressive Strength of Cubes with and without Fibers

3.2 Split Tensile Strength

The cylinders of size 100 mm diameter and 200 mm height are tested in hydraulic compression testing machine of 2000 kN capacity as shown in Fig. 3.3. The values of split tensile strengths obtained are shown in Table 3.2 and Fig. 3.4. The split tensile strength of para aramid fiber reinforced concrete cylinders increased by 135.686% in comparison to control concrete cylinder [12].

Fig. 3.3: Split tensile test on cylinder

Table 3.2: Average Split Tensile Strength Test Result of Cylinders

Specimen ID	Percentage of Fiber	Split Tensile Strength (MPa)	Average Split Tensile strength (MPa)
A1	0%	1.39	1.45
A2		1.46	
A3		1.50	
B1	1%	1.75	1.91
B2		2.07	
B3		1.91	
C1		2.54	

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C2	2%	2.23	2.54
C3		2.86	
D1	3%	3.03	3.66
D2		3.66	
D3		4.29	
E1	4%	5.25	5.56
E2		5.57	
E3		5.88	

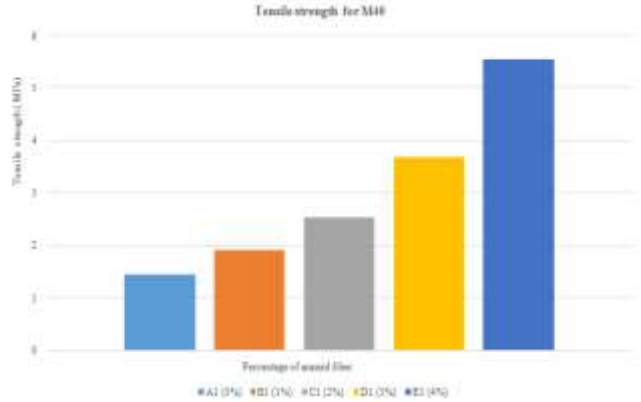

Fig 3.4: Comparison of Split Tensile Strength of Cylinders with and without Fibers

3.3 Discussions on Compressive Strength and Split Tensile Strength of Para Aramid Fiber

- For M40 grade concrete, there is an increase in compressive strength of 2.39%, 10.76% and 27.68% for 2%, 3% and 4% of para aramid fiber compared to conventional concrete. Hence, addition of para aramid fiber resist micro cracking as compressive strength of concrete increases.
- For M40 grade concrete, there is a decrease in compressive strength of 8.33% for 1% of para aramid fiber compared to conventional concrete.
- For M40 grade concrete, there is an increase in split tensile strength of 31.724%, 75.172%, 152.41%, and 283.44% for 1%, 2%, 3%, and 4% of para aramid fiber compared to conventional concrete. Hence, it can be concluded that by increasing the percentage of para aramid fiber increases the split tensile strength.

4. CONCLUSION

- While increasing the percentage of para aramid fibers with increases the compressive strength and split tensile strength.
- The compressive strength of M40 concrete with addition of para aramid fibers increase by 12.48% when compared to conventional concrete. Hence, addition of para aramid fibers resist micro cracking.
- The split tensile strength of M40 concrete with addition of para aramid fibers increased by 135.69%. Hence, addition of high modulus of para aramid fiber increases tensile strength of concrete.

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